Annals of Clinical and Analytical Medicine
Original Research

Applicability of the modified Demirjian's method for age estimation in a sample of Egyptian children using dental radiography

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Abstract

Aim: Age estimation is a challenging task in forensic practice. Teeth are employed primarily in the age estimation of children as a result of their low variability and less exposure to environmental, endocrine and nutritional factors. Thus, the current study aimed to test the applicability of the modified Demirjian method on a sample of Egyptian children.

Material and Methods: Panoramic radiographs of 140 randomly selected individuals (70 males and 70 females) aged from 8 to 18 years were evaluated based on the modified Demirjian's method.

Results: In males, there was a statistically significant correlation between chronological age (CA) and dental age (DA) using the modified Demirjian method; this method underestimated the age in all age groups by 0.45 to 1.77 years, with the exception of age group 10, where overestimation by 0.05±0.07 years was found, dental age (DA) was underestimated in males with an overall mean difference of 1.30 years. In females, there was a statistically significant correlation between chronological age (CA) and dental age (DA). DA was underestimated by 0.20 to 2.38 years in all groups, except for group 13, where overestimation was noticed by 1.20±0.94 years, DA was underestimated with an overall mean difference of 1.27 years.

Discussion: Age estimation using the modified Demirjian's method narrows down the mean difference of age to less than one year in some age groups, especially in early adolescence in both sexes; however, the applicability of the current method in the identification of certain age groups among Egyptian children should be taken with caution because of significant results variations. Thus, in these age groups, it is advisable to confirm the estimated age using adjuvant methods.

Keywords

Age Estimation; Dental Age; Forensic Odontology; Challiet–Demirjian; Modified Demirjian's Method

DOI: 10.4328/ACAM.20637 Received: 2021-04-05 Accepted: 2021-05-12 Published Online: 2021-06-27 Printed: 2021-09-15 Ann Clin Anal Med 2021;12(Suppl 4): S456-460
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Introduction

Age estimation is an integral part of forensic investigations with an alarming increase in crimes involving juveniles worldwide. Marriage validation and child work are amongst other related issues that require accurate age estimation [1].

Identification of age among children can be done using skeletal, dental, anthropological and physiological methods. Dental development is a useful indicator of maturation because it is highly reliable with a low coefficient of variation, and resistance to environmental factors [1, 2].

Dental age estimation methods have become popular in recent years due to simplicity and less time requirement. Several age estimation methods were created depending on dental development pattern using panoramic radiographs and hence different standards had been established [1].

Currently, Demirjian's method is the most commonly used method for children; it is based on French-Canadians. According to this method, orthopantomograms (OPGs) are utilized to assess the extent of mineralization (calcification) of dental tissues and the stage of maturation of the seven left permanent mandibular teeth from the central incisor to the second molar [2].

It was reported that Demirjian's method was less accurate when conducted on populations other than the original population (French-Canadians). These results revealed the necessity to establish standards representative of each population; therefore, some researchers modified Demirjian's method using standards based on their population data [3].

The original Demirjian's method excluded the third molar due to its variability. As a result of its exclusion, the original Demirjian's method is not suitable for age estimation after about 16 years of age [4, 5].

The third molar offers the only reliable radiological parameter for age estimation in the age group of 16–23 years. Yet, it was concluded by Mincer et al. (1993) that a third molar may indicate with reasonable accuracy that a person is at least 18 years of age, rather than giving an exact chronological age, due to the absence of any other marker in the late adolescence [6].

In 2004, Chaillet and Demirjian conducted a research with 1031 dental panoramic radiographs of healthy southern French subjects aged between 2 and 18 years and implemented new dental developmental scores for children. A modification of the original Demirjian's method was done to increase applicability to 18-year-old individuals by including a third molar [7].

Since few studies have evaluated dental maturation techniques in Egypt, the aim of the present study was to assess the applicability of modified Demirjian's method for age estimation among a sample of Egyptian children.

Material and Methods

The study was conducted in the Department of Orthodontics, Faculty of Dentistry, Alexandria University, following the ethical approval from the Ethics Committee of the Faculty of Medicine, Alexandria University (FWA number: 00018699, IRB number: 00012098, approval serial number: 0201226). Parents/guardian agreements were obtained in each case.

Sampling method: In this cross-sectional observational study, panoramic radiographs of 70 randomly selected males and 70 randomly selected females were collected.

Sample size: Based on previous studies, the Pearson correlation between chronological age and estimated age among males and females was 0.882 and 0.956 respectively. Using alpha error =5% and study power of 85%, the minimum sample size required is 140 children, with 70 children for each group. The sample size was calculated using G. Power software

Inclusion criteria: Panoramic radiography was done for each patient as part of the patient investigation protocol. Only patients with confirmed chronological ages were included.

The age of participants ranged from 8 and 18 years. Only healthy individuals with a complete set of eight mandibular permanent teeth from the central incisor to the third molar whether erupted or not were included.

Exclusion criteria: children with unconfirmed chronological age, individuals with congenital anomalies, local trauma affecting the primary teeth, gross pathological problems and systemic diseases or growth disorders were excluded. Also, distorted radiographs due to faulty position or movement during exposure, or unclear images were excluded.

Calculation of dental age (DA) by Chaillet-Demirjian (modified Demirjian) method: dental age estimation was done by evaluating the digital radiographs and determining the stage of maturation (calcification) of each tooth of the 8 left mandibular teeth. The maturity score of each tooth was assigned (Figure 1) [5]. The sum of maturity scores of all 8 teeth was obtained and designated as the ' maturity score = S ' for each subject (Tables 1 and 2). Dental age was measured using a special formula for each sex, involving this maturity score [7].

Age in males = (0.0000550 × S3) – (0.0095 × S2) + (0.6479 × S) – 8.4583.

Age in females = (0.0000615 × S3) – (0.0106 × S2) + (0.6997 × S) – 9.3178.

Examples of evaluation of dental maturity score and the calculated dental age of both sexes were demonstrated in Figure 2 in males and Figure 3 in females.

The difference between the calculated dental and chronological age was tabulated and compared statistically.

Reproducibility of measurements: Two trained forensic physicians analyzed all images separately. To assess intra-observer reliability, the first examiner reevaluated a randomly selected 30 radiographs after 2 weeks at least. To test inter-observer reliability, examination of randomly selected 30 radiographs (15 males and 15 females) by the first and the second examiner was conducted.

Statistical analysis:

The obtained data were tabulated and analyzed using SPSS version 20.0 (IBM, Armonk, New York, USA). The intra-class correlation coefficient (ICC) was used to evaluate intra-and inter-observer agreement and the repeatability between measurements. The Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to test the normality of the data. A positive result indicated an overestimation, and a negative result indicated an underestimation of age. The correlation between dental and chronological age was analyzed using Spearman's rank correlation coefficient.

Results

The intra-class correlation coefficient (ICC) value for the inter-observer reliability was as high as 0.93, indicating excellent reliability. The repeatability between the measurements for the

same observer (intra-observer agreement) was also high (0.95). Comparisons between the mean ages calculated using the Chaillet-Demirjian (modified Demirjian) method and the mean chronological age showed the following results:

Table (1) shows that the mean chronological age for males was 12.07±2.89 years, while for females it was 12.42 ± 2.72 years. The mean age calculated by the Chaillet-Demirjian method was 11.04±3.05 years in males, with a mean difference of 1.30 ± 1.30 years compared to the chronological age. Regarding females, the mean dental age was 11.15±3.09 years with a mean difference of 1.27 ± 1.59 years compared to chronological age. This method showed an overall underestimation of the calculated dental age in both sexes. A statistically significant difference between the calculated dental age and chronological age in both sexes was noticed, where P < 0.001, as shown in Tables 2 and 3).

In males, the Chaillet-Demirjian's method underestimated the age in all age groups by 0.45 to 1.77 years, except for age group 10, where an overestimation by 0.05±0.07 years was found. Regarding age groups, the mean difference was < ±1 year in the 9, 10, 12, 13 age groups, while it was > ±1 year in the 8, 11, 14, 15 and 17 age groups (Table 2).

Table 3 also shows that in females, an underestimation of the age by 0.20 to 2.38 years was observed in all groups, except for group 13, where an overestimation was noticed by 1.20±0.94 years. The mean difference was < ±1 year in the 11, 12 age groups, while it was > ±1 year in most age groups (8, 9, 10, 13-16).

The results of the Spearman correlation coefficient test, performed for males and females, showed a strong linear correlations between the chronological age and the Chaillet-Demirjian dental age, r value was 0.918 in males and 0.858 in females.

Table 1. Distribution of the studied sample by age and sex (n=140)

Age group (years)	Age range (years)	Sex	Number%	Mean age±SD (years)	Median (years)
8	8-8.9	Males	13(18.57%)	8.58±0.29	8.60
		Females	11(15.72%)	8.42±0.34	8.30
9	9-9.9	Males	10(14.28%)	9.33±0.26	9.30
		Females	6(8.57%)	9.48±0.31	9.55
10	10-10.9	Males	4(5.72%)	10.12±0.05	10.1
		Females	4(5.72%)	10.15±0.17	10.15
11	11-11.9	Males	8(11.43%)	11.47±0.26	11.5
		Females	9(12.85%)	11.36±0.2	11.4
12	12-12.9	Males	6(8.57%)	12.60±0.39	12.8
		Females	8(11.42%)	12.12±0.12	12.1
13	13-13.9	Males	12(17.15%)	13.17±0.19	13.15
		Females	4(5.71%)	13.2 ±0.17	13.25
14	14-14.9	Males	3 (4.28%)	14.76±0.15	14.8
		Females	12(17.15%)	14.36±0.27	14.3
15	15-15.9	Males	6(8.57%)	15.13±0.05	15.1
		Females	8(11.43%)	15.33±0.31	15.25
16	16-16.9	Males	0	0	0
		Females	6(8.57%)	16.28±0.31	16.1
17	17-17.9	Males	8(11.43%)	17.37±0.39	17.2
		Females	2(2.86%)	17.00	17
Total	8-18	Males	70(100%)	12.07±2.89	11.95
		Females	70(100%)	12.42 ± 2.72	12.10

SD: standard deviation

Table 2. Comparison of chronological age and Chaillet-Demirjian dental age in males

Age group (years)	Mean ± SD (years)	Mean difference (years)	Median (years)	P value#
8	6.89±0.48	- 1.69± 0.38	7.01	<0.001
9	8.78±0.84	- 0.55±0.49	8.51	0.093
10	10.17±0.49	+ 0.05±0.07	10.17	0.461
11	10.45±0.96	- 1.02±1.10	10.9	0.036
12	12.04±1.41	- 0.45±0.70	12.46	0.462
13	12.72±1.9	- 0.45±1.03	12.83	0.456
14	12.99±2.3	- 1.77±2.42	14.32	0.109
15	13.45±1.79	- 1.68±1.80	14.41	0.028
16	0	0	0	0
17	15.80±0.11	- 1.57±0.39	15.83	0.012
Total	11.04±3.05	- 1.30 ± 1.30	10.60	<0.001

#Wilcoxon Signed Rank test: p ≤ 0.05 = significant

Table 3. Comparison of chronological age and Chaillet-Demirjian dental age in females.

Age group (years)	Mean ± SD (years)	Mean difference (years)	Median (years)	P value#
8	6.79±0.45	- 1.63 ±0.60	6.80	0.005
9	8.35±0.69	- 1.13±0.57	8.32	0.027
10	7.77±1.55	- 2.38±0.98	7.86	0.068
11	10.61±1.79	- 0.75±1.70	11.77	0.374
12	11.92±2.01	- 0.20±2.05	11.16	0.673
13	14.42±0.95	+ 1.20±0.94	14.42	0.068
14	12.41±1.83	- 1.95±1.79	12.54	0.008
15	13.23±1.92	- 2.10±1.74	13.78	0.012
16	15.05±0.15	- 1.23±0.23	14.49	0.027
17	15.25±0.00	- 1.75±0.00	15.25	0.157
Total	11.15±3.09	- 1.27 ± 1.59	11.85	<0.001

#Wilcoxon Signed Rank test: p ≤ 0.05 = significant

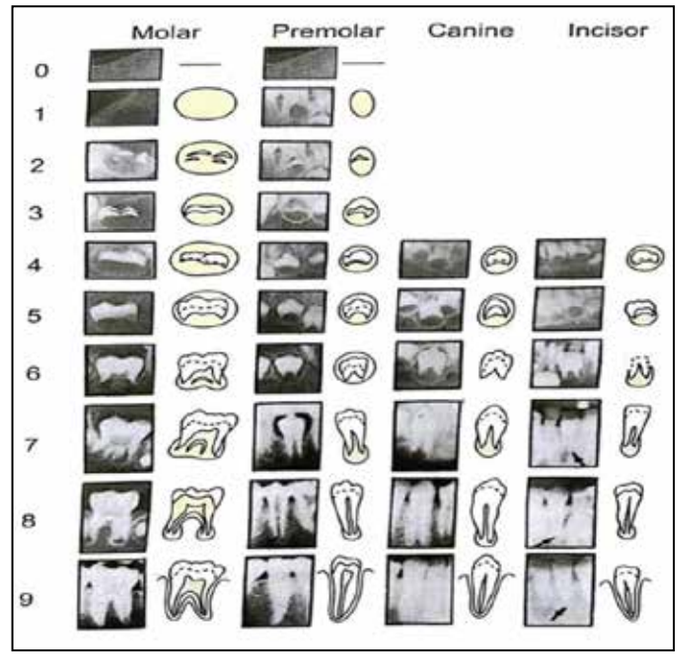

Figure 1. Stages of teeth development (mineralization) from 0-9 according to the modified Demirjian method [5].

Figure 2. Panoramic radiograph of male patient showing different stages of teeth maturation; chronological age is 12.75 years, age according to the modified Demirjian method is 12.42 years.
Central incisor: stage 9, Lateral incisor: stage 9, Canine: stage 8, First premolar: stage 9, Second premolar: stage 8, First molar: stage 9, Second molar: stage 8, Third molar: stage 5
Maturity score = 87.84
Dental age = (0.0000550 × S3) – (0.0095 × S2) + (0.6479 × S) – 8.4583.
(0.0000550 × 87.843) – (0.0095 × 87.842) + (0.6479 × 87.84) – 8.4583= 12.42 years

Figure 3. Panoramic radiograph of female patient showing different stages of teeth maturation; chronological age is 9.5 years , age according to the modified Demirjian method is 9.72 years.
Central incisor: stage 9, Lateral incisor: stage 9, Canine: stage 7, First premolar: stage 7, Second premolar: stage 7, First molar: stage 9, Second molar: stage 7, Third molar: stage 5.
Maturity score = 76.59
Dental age = (0.0000615 × S3) – (0.0106 × S2) + (0.6997 × S) – 9.3178.
= (0.0000615 × 76.593) – (0.0106 × 76.592) + (0.6997 × 76.59) – 9.3178=9.72 years.

Discussion

There has been a terrifying increase in the number of unidentified corpses and human remains, as well as the rising number of cases requiring age estimation, especially among refugees and individuals with no valid proof of date of birth. This is a result of territorial mobility and migration accompanying political changes in the Middle East [8-11].

There are different patterns of dental development recognized among different populations; therefore, no universal method for age estimation can be applied to every population [12, 13].

The sample in the present study was divided into males and females because of the widely-reported prevalence of sexual dimorphism in dental development [3].

In the present study, only the mandibular teeth were evaluated, as radiographs of the developing maxillary permanent teeth are often obstructed by the bony structures of the maxilla, while teeth of the mandible, on the other hand, are quite clearly visible in an OPG [3].

Since the presence of a very high degree of symmetry between the teeth of the left and right sides has been well-established, only the mandibular teeth of the left quadrant were evaluated [3].

The original Demirjian method was tested in a sample of Egyptian children in two different governorates (Tanta and Minia) and showed an overestimation for both sexes. In Tanta in 2016, an examination of a sample of panoramic radiographs of Egyptian children showed an overestimation of age for almost all the studied subjects [14].

Three years later, in 2019 in Minia, the same results were reported as both boys and girls showed advanced dental age compared with their chronological age [15]. Both studies concluded that the Demirjian standards were not applicable to Egyptian children [14, 15].

To date, the modified Demirjian method (Challiet-Demirjian method) was not applied to Egyptian children yet. Thus, the present study evaluated its applicability among Egyptian children.

Results in the current research revealed that the Challiet-Demirjian method underestimated the age by a mean difference of more than 1 year for both sexes. In males, the mean age calculated by the Chaillet-Demirjian method was 11.04±3.05 years with a mean difference of 1.30 ± 1.30 years compared to chronological age. In females, the mean dental age was 11.15±3.09 years with a mean difference of 1.27 ± 1.59 years compared to chronological age.

There was a statistically significant difference between the calculated dental age and chronological age in both groups. In males, a mean difference of one year was recorded in the 9, 10, 12, 13 age groups, while it was > ±1 year in the 8, 11, 14, 15 and 17 groups. Whereas, in females, the mean difference was < ±1 year in the 11, 12 age groups, while it was > ±1 year in most age groups (8, 9, 10, 13, 14, 15, 16). It is important to consider the presence of clinically significant results in the absence of a statistically significant difference due to a small sample size in certain age groups.

In agreement with the results of the present study, underestimation of age was noted in Mohammed et al.'s study (2014). However, they found that the modified Demirjian's method underestimated the mean age of males by 0.8 years and females by 0.5 years among southern Indian children, and also showed that females mature earlier than males in the selected population [16].

Likewise, the results of another study in India that included 250 individuals showed that the modified Demirjian's method underestimated dental age by 0.84 years in males and 0.83 years in females [17].

The same findings were concluded in the study by Cruz-Landeira and Linares-Argote in 2010. In that study, the original method and the modified Demirjian method were tested on Spanish and Venezuelan children. In the Venezuelan Amerindian sample, the original Demirjian's method underestimated the age, and the

underestimation was even higher when the modified method was applied [18].

Dental maturity in Korean juveniles and adolescents was assessed using the modified Demirjian method as well; an underestimation of the dental age was observed with a mean difference of 0.38 and 0.31 years in males and females, respectively [19].

Another study, which was conducted upon Kosovar children showed that underestimation was noticed by 0.24 years and 0.35 years in males and females, respectively [20].

In contrast to the previous studies, the modified Demirjian's method overestimated DA when compared to CA in some other studies.

Kumar and Gopal in 2014 used the modified Demirjian method among a sample of Indian children; the study included radiographs in the age range from 7 to 23 years for both boys and girls, and overestimation of DA for both males and females was reported, which might be due to the inclusion of third molars, as they explained [3].

Furthermore, Tandon et al. (2015) also observed an overestimation of DA in Indians. The mean estimated age was found to be significantly higher compared to CA for the overall sample as well as both sexes. The mean age difference was 0.85 years for males and 0.87 years for females [21].

Conclusion and Recommendations:

The results of this method could be reliable among some age groups (9, 10, 12, 13) in males and (11,12) in females, since the mean difference between the calculated dental age and chronological age in these groups was less than one year.

The underlying stages of tooth calcification proved to be sound as the observed levels of inter and intra-observer agreements were high. However, the applicability of the current method in the identification of age in certain age groups among Egyptian children should be taken with caution because of significant variations in results. Thus, in these age groups, it is advisable to confirm the estimated age using adjuvant methods.

Using a larger sample size should be employed to achieve the most accurate age assessment, also population-specific standards and specific regression formula for both sexes should be considered.

The introduction of adaptable conversion tables to transform the maturity score into a dental age for Egyptian children is advisable and may be a suitable alternative.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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How to cite this article:

Abeer Abd Elmoneim Sheta, Nagwa Mostafa Enany, Naglaa Hassan Salama, Rania Abd Elmaguid Ahmed, Marwa Ismail Mohamed Haiba. Applicability of the modified Demirjian's method for age estimation in a sample of Egyptian children using dental radiography. Ann Clin Anal Med 2021;12(Suppl 4): S456-460